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The National Cooperative Soil Survey in the United States

By Roy D. Hockensmith, Soil Conservation Service

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FOREWORD

Fortunately, we in the United States have many kinds of good soil. Altogether there are about 75,000 kinds including those that are good and those that are not so good. We have a large total area of the good ones. Thus, American land users have a wide choice. We do not need to use every acre for food crops as do people in many crowded countries. Some day we may have greater need, but now it is not really necessary for our people to use soils for crops that cannot return a good harvest for the labor and materials used in production. Our main goal is efficiency of use on a sustained basis.

Our ever-widening technology of soil use has increased the total area available for crops. Soils that are unproductive with the old methods are productive with the new ones. We are continually learning how to build up their productivity and to use them more efficiently. American farmers are steadily improving their practices. Soil conservation is making good progress.

Our soils exist as small areas. These soil areas are commonly intricately mixed. Thus to apply our knowledge and to make the best choices for a farm plan a soil map is required.

Making this map is the job of the Soil Survey. First, the soils must be examined in both field and laboratory to learn their characteristics, how they were formed, and how they are now changing. Then the soils can be classified and given names in the national system. The boundaries between the different kinds are plotted on aerial photographs or maps of large scale. Finally, a text that goes with the published map explains their potential use and behavior.

This publication highlights how soil surveys are made and used as the basis for rational land use in our country.

Charles E. Kellogg
Assistant Administrator for Soil Survey
Soil Conservation Service

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The National Cooperative Soil Survey in the United States

Roy D. Hockensmith, Director, Soil Survey Operations, Soil Conservation Service

In the United States soil surveys are made cooperatively by Federal and State Government people. The Federal agency that has primary responsibility for them is the Soil Conservation Service (SCS) of the U. S. Department of Agriculture. The Land-Grant Colleges and Universities (primarily State agricultural experiment stations) are the State agencies. In some surveys others also cooperate including such Federal agencies as the Forest Service, Bureau of Indian Affairs, Bureau of Reclamation, and Bureau of Land Management; such State agencies as the departments of natural resources, conservation, or agriculture, and the geological survey; and to an increasing degree such local agencies as county governments and other local units of government. This joint effort, started in 1899, is called the National Cooperative Soil Survey.

Maps showing coverage by "Recent Soil Surveys" and "Published Soil Surveys" accompany this publication. About one-half of the land in farms in the United States (about 640 million acres) has been covered by soil surveys that show enough detail for conservation planning. This is about one-third of the total land area of the United States.

Soil surveys of another 200 million acres are useful but lack one or more essential details, primarily because of small scale and because at the time they were made soil surveys were not designed for use as a basis for detailed technical assistance.

The present rate of soil mapping is about 50 million acres per year. This is done by about 1,200 soil scientists in the field supported by some 200 additional scientists.

Land-capability groupings of the soils shown on the maps are made to introduce users to the detailed map and the soil descriptions. This interpretation is widely used in giving technical assistance to farmers and ranchers through soil conservation districts.

HOW SOIL SURVEYS ARE MADE

Plans for a Survey

Plans for work in each area to be surveyed are developed cooperatively by the agencies involved. These plans show by name who is to be the local survey-party leader, who is to do the mapping, and who is to write the report, and state when these things are to be done. The scale of maps and the intensity of detail of mapping are agreed upon as are the plans for publication.

Mapping Legend

At the beginning of the survey an experienced soil scientist usually from the State SCS office takes the leadership. He and the local survey-party leader and representative of each cooperating agency travel over the area to be covered studying the soils. They prepare a mapping legend. The legend lists and describes the soils they then know will be shown in the survey. It also gives the symbol to be used to identify each.

Examining Soils in the Field

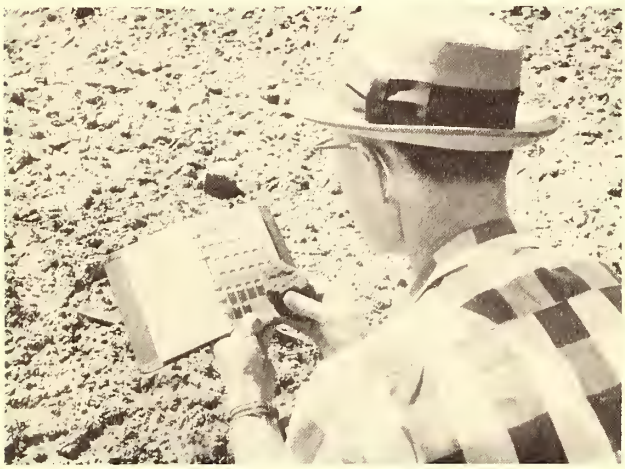
The soil scientists in the survey party then map the soils in the field. Their knowledge of the relation of landscape features, climate, parent material, relief, and vegetation to soil properties aids them in predicting the kinds of soil they expect to find. But to study the soil adequately, they dig or bore numerous holes deep enough to examine the underlying layers.

They record the total thickness of the soil, the thickness of each horizon, and its position in the profile. Commonly, properties of each horizon are contrasting; so for each one they note its texture (size of soil particles), structure (arrangement of soil particles), color, and

THE STEREOSCOPE helps soil scientists draw preliminary lines on aerial photographs to separate obvious differences in landforms. This step saves much time in the field. Depending on the landscape, it may cut the cost of the soil survey by 20 percent.

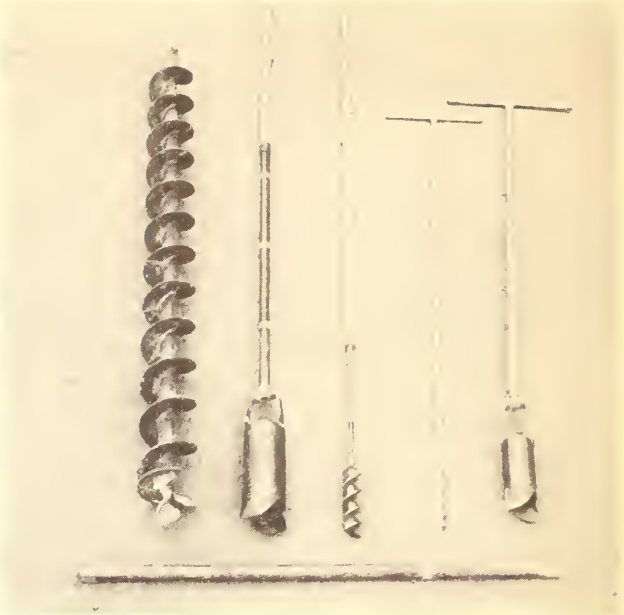
[1] Prepared primarily for participants at the Seventh Congress of the International Society of Soil Science, Madison, Wisconsin, August 14-23, 1960.

AN ADJUSTABLE HAND LEVEL for reoding slope is o port of every surveyor's equipment.



A SOIL COLOR CHART, mode up of some 200 color chips systemoticolly orronged, mokes it possible for soil scientists to give stondord notations to the color of the soil.

BACKHOE DIGGERS sove time ond hond lobor in digging pits 4 to 6 feet deep for coreful exominotion of o soil ond for collecting soil somples for loborotory determinotions.



SOIL AUGERS like these ore used extensively in humid regions for identifying soil. Most hond ougers go down 42 inches, or deeper with extensions.

EACH HORIZON is studied corefully in o pit deep enough to expose the complete soil profile.

acidity or alkalinity. They also record other characteristics, especially those having to do with the behavior and potential productivity of the soil as a whole.

Slope of the soil surface, significant losses of soil by erosion, stoniness, salt accumulation, and evidences of imperfect drainage or flooding and the like are also recorded.

From these observations, supplemented in some instances by laboratory data on samples of the horizons, they estimate permeability of the soil, erosion hazard, and other qualities important to soil use.

Of course, no two soils examined are exactly the same. But those soils that do not have differences that are significant in soil genesis and soil use are placed together and given a symbol for the map, and the boundaries are plotted on the map.

Many soil-mapping units merge into one another through a transitional belt several yards or more wide. Hence, the boundary on the map may indicate an abrupt or a gradual change in soil.

The soil scientist includes additional information about the landscape needed by users of the survey such as the drainage pattern (how and where water flows from the land) and the position of rock outcrops, lakes, ponds, levees, roads, railroads, power lines, geographical boundaries, buildings, and the like.

Equipment Used

To see the many soil characteristics--to mentally integrate them into mapping units to be recorded on the map--the soil scientist must not only be properly trained; he must also be properly equipped. The methods and the tools he uses depend on where he is working. After having a few deep trenches dug mechanically, in some places he needs only a spade or hand auger to examine the soil characteristics. But in another part of the country, he may use a power auger and other equipment to get the information he wants.

Much information is gained with a spade--the depth of the surface horizon, the soil texture (coarseness or fineness), and the structure of the surface soil and the top part of the subsoil. In other words, with the spade a soil scientist can uncover and see all the characteristics of the soil that are within reach that way. And the spade does not distort the soil structure as do some soil augers. If deeper examinations are needed, he uses a soil auger.

A 42-INCH POWER PROBE mounted on o four-wheel drive pickup, being used to get undisturbed samples to exomine in the field.

The open "window" of the probe permits soil scientists to check texture structure, consistence, ond color ony of the profile.

Laboratory Work

While making the survey, the soil scientist also collects soil samples by soil horizons to be studied in the laboratory. This means he must dig a pit deep enough to reach through all the horizons and into the material beneath the true soil and large enough so that he can get into the pit and work effectively.

The samples are placed in bags or cans, labeled, and sent to a laboratory. The samples taken depend on the type of examinations to be made. And these in turn depend on the problem of soil classification, of genesis, or of behavior to be solved. For most analyses loose samples of about a gallon from each horizon are satisfactory.

The soil scientist takes undisturbed core soil samples where laboratory analyses are needed to study how porous the soil is, how fast water moves through it, how dense it is, and similar physical measurements.

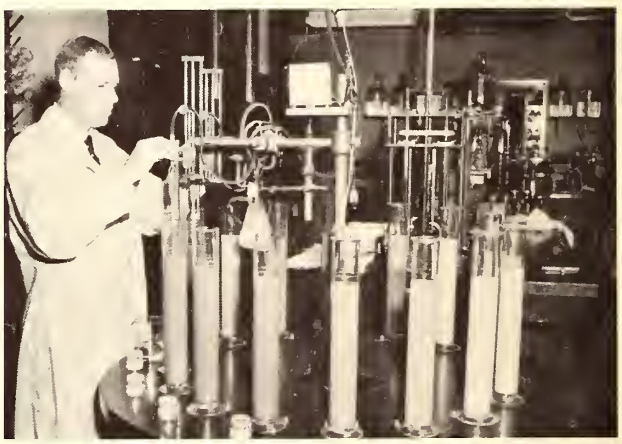
In the laboratory a scientist measures particle-size distribution to help estimate the water-holding capacity. He measures the rate that water moves through the soil. He studies thin sections of the soil under the petrographic microscope to learn the distribution of certain important minerals.

These laboratory studies make it possible to use the information available on one soil for predictions about other soils with similar characteristics and qualities.

At the same time they reveal information that helps in putting all this soil information into use. For example, tests on water-holding capacity may open up new possibilities for the irrigator. Or the drainage engineer who knows the rate of water movement through the soil can space tile for effective water disposal or know where tile will not work so well as open ditches.

SOIL SAMPLES FROM EACH HORIZON being bagged to send to the laborotory.

UNDISTURBED SOIL SAMPLES are token for laboratory determination of bulk density of the soil.



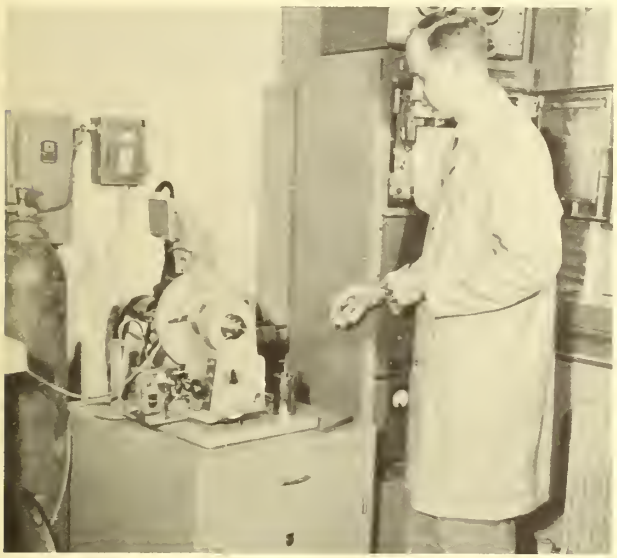
DETERMINING CLAY CONTENT--usuolly the most important minerol froction of the soil.

MICROSCOPIC STUDY gives voluable informotion about soils just as it does in plant research. This soil scientist is making a photomicrograph of a section of soil that has been ground to a thickness of .03 mm.

Data from laboratory tests for calcium, magnesium, potassium, and other elements in soils help the scientists predict how these soils will respond to certain fertilizers.

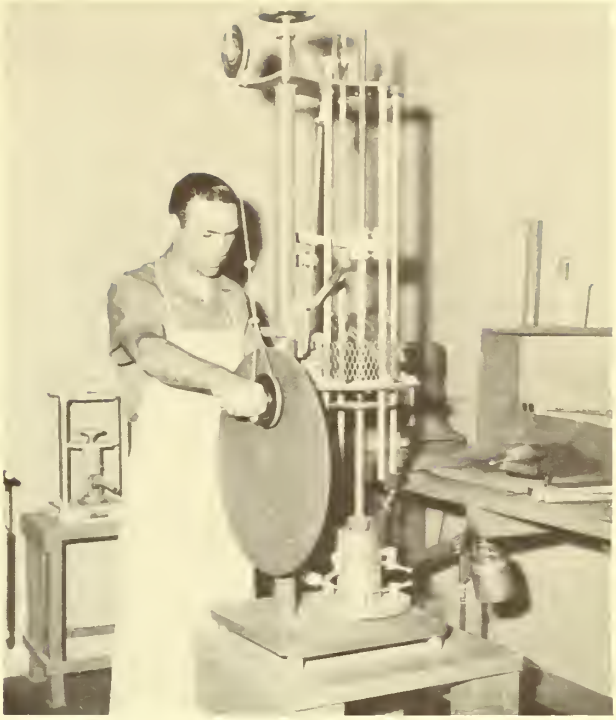
And the results of laboratory studies help the soil scientist in the field by giving him standards to go by; for example, he estimates soil texture in the field by rubbing soil between his thumb and finger. The laboratory measurement of the percent of sand, silt, and clay gives him a good check on his ability to estimate texture in the field.

Where information is needed for highway construction or other engineering uses, 30-pound samples are taken. This provides enough soil for the mechanical analysis and other tests to determine how the soil may be compacted



X-RAY FLUORESCENCE ANALYSIS is used in making rapid determinations of elements in the soil.

EXCHANGEABLE CATIONS and exchange capacities of soils are determined in the laboratory. The results of these determinations are used in classifying soils and in predicting their field behaviar.



SAMPLES OF SOIL MATERIAL are sent to soil-mechanics laboratories for the purpose of specifying the moisture content and density of compacted fill.

and its other engineering properties. Most of these determinations are made by the Bureau of Public Roads and State Highway Department laboratories.

Soil Descriptions

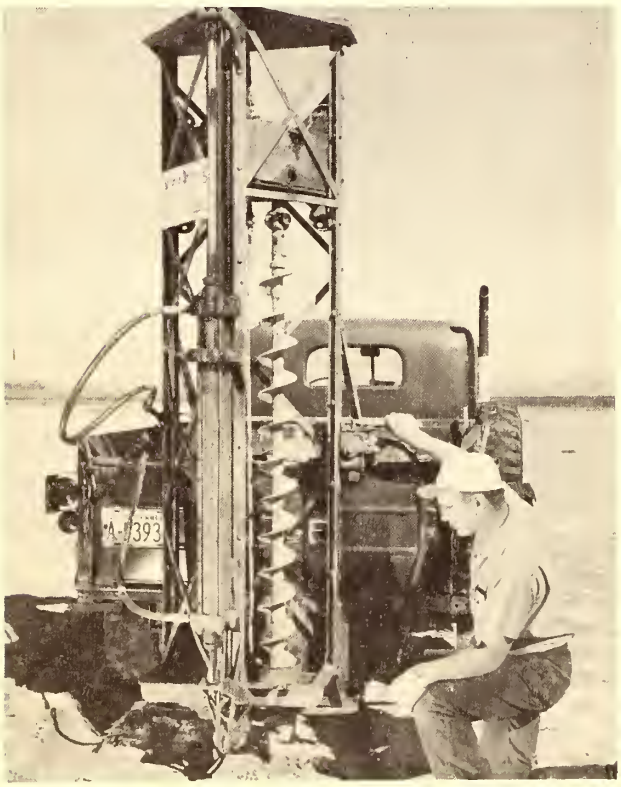
As the soil scientist does his mapping, he adds new or improved information to the mapping legend and writes descriptions of the new soils he maps. During the course of the survey he writes several descriptions of each mapping unit. These include the location and description of a representative profile in each. From his several descriptions he prepares a composite description of each mapping unit and a statement explaining how much range was allowed in the various characteristics. He describes "inclusions" outside the range of the soil that bears the name assigned to the mapping unit.

He describes soils in standard terms[2] so they can be used by other soil scientists who map in the area or who make use of his work. This provides enough information so that the soils can be classified properly and related properly to other soils outside the area.

The notes taken by the soil scientist are organized systematically for reference during the survey. As soon as the work is well begun they are assembled into handbooks and technical guides for use in farm-conservation planning

[2] Soil Survey Manual. U.S. Dept. Agr. Handbook 18. 1951.

SOIL PROFILE MONOLITHS are used for training and for displays to show the characteristics of each horizon. This picture shows one of the steps in removing a monolith from a pit.



A MOBILE POWER AUGER being used to obtain large soil samples of deep material for examination in drainage and watershed work. Here the operator is using a 6-inch auger bit, power driven from the truck. It can be driven down as much as 20 feet.

DEPTH TO WATER TABLE being determined by dropping a terminal down a pipe pushed several feet into the ground. Needle movement in the meter shows when the terminal touches water, which completes an electrical circuit.

and other applications, and for preparing the final soil-survey report to be published for the area.

Collecting Additional Information

To give technical soil assistance for some special purposes, such as in designing drainage systems, deep borings must be made to add to the information normally collected. Checking foundation material on which to build heavy structures or highways and checking the porosity of deep layers that may cause a pond to leak are other examples of this kind of on-site assistance.

Information on flooding usually is recorded in making a soil survey. This kind of information is used in interpreting soil maps in planning and carrying out watershed-protection and flood-control work.

Strongly alkaline soils and those containing harmful amounts of salts are mapped separately from other soils. Soils having enough soluble salts or alkalinity to interfere with growing crops are largely confined to the arid and semiarid regions in the United States. They also occur, however, in humid regions in coastal strips affected by tides and in local areas affected by seepage of salty waters. One of the principal purposes of detailed soil surveys in such areas is to identify soils that cannot be irrigated practicably and to suggest potentialities and methods of reclamation and use for those that can be used for crops.

Soil Investigations

Research develops new ideas that increase our understanding of soils, makes soil surveys more useful, and increases efficiency of map-

WHEATSTONE BRIDGE ond cell for meosuring solinity.

ping. For example, the results of a study on landscape evolution and soil genesis in an arid area near Las Cruces, N. Mex., is increasing our understanding of the nature of soils and erosion processes in desert areas. Field studies on other projects such as (1) relations between soil-moisture movement and horizons of clay accumulation, (2) gullying in Western Iowa, (3) soil-plant relations on rangeland, (4) relations of deficiencies of cobalt and toxicities of molybdenum to soil classification are revealing data that make possible soil surveys of higher quality.

Results of studies on the relations between climate and crop yields by soils in the Great Plains and other areas are improving the placement of soils in the land-capability classification.

Soil Correlation

To extend information obtained on one soil to like soils in other areas requires that these soils be given the same name. Briefly, one of the immediate purposes of soil correlation is to assign names to the soils in the mapping units that are shown on soil maps. These, of course, must be consistent with and fit into the nation-wide system of soil classification. Moreover, the name of a soil in a given area must carry the same name as soils in other areas that do not differ significantly in soil genesis or soil use.

Accurate mapping and interpretation depend on accurate classification. And, in turn, the mapping and interpretation serve as tests of the classification.

A pamphlet by Charles E. Kellogg entitled "Soil Classification and Correlation in the Soil Survey" is available from the Soil Conservation Service.

GEOLOGISTS work with soil scientists to study the relotionship of porent moteriol to soil formotion.

SOIL CORRELATORS exomine mony soils in the field with the soil surveyors prior to fitting the soils into the notionwide system of soil classificotion.

Cartographic Work

After the field mapping is completed for an area, usually a county, the soil information is transferred from the field sheets to a photomosaic base for printing the soil map.

By using a photomosaic base much drafting is eliminated and at the same time more background detail is included. The photomosaic shows such details as field boundaries, broad land use, and minor roads or trails that usually are not shown on line base maps.

The publication scale is commonly 1:20,000, which is usually large enough for users to see clearly the relation of soil boundaries to local land features in specific fields.

A few of the several map-making steps are illustrated here.

A PHOTOMOSAIC of the entire survey area is prepared for use as a base for the printed soil map. Because of land irregularities, each photograph must be rectified to fit an established ground-control network shown by the small white circles.

SOIL INFORMATION symbols and boundaries are being transferred from the field sheet to a coated plastic sheet placed over the photomosaic map. Scribing through the coating to the plastic beneath leaves transparent lines (white on this illustration). This scribed sheet becomes a negative used in making the printed map.

All map sheets are edited for accuracy, legibility, and completeness. Editing is done on a composite print of all the color-separation plates without the photomosaic background.

USING SOIL-SURVEY INFORMATION

Information about how soils respond to different management and treatment is gathered from many sources. Farmers' own experiences and field trials provide much information. More precise information is gained by experiment stations and other laboratory and field experiments where tests are made under controlled conditions. As information is collected on one soil or on a group of related soils, it can be projected to other soils.

Because there are so many kinds of soils, there are many individual soil interpretations. Most users of soil surveys want more general information than that of the individual mapping unit. They would like to have grouped together, for example, soils that behave alike in response to management and treatment for specific uses. Such grouping results in wider and more efficient use of what is known about soils.

The land-capability classification is one interpretative grouping. It helps to introduce agricultural users to the detailed soil map. Soils are grouped according to their adaptability for common farm crops under permanent agriculture, to what they can be expected to do, to their limitations for sustained production, and to the risk of soil damage if they are mismanaged.

In this classification the individual mapping units are first grouped into capability units.

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The soils in any one capability unit have similar risks and limitations for agricultural use, respond to the same broadly defined practices, are adapted to about the same farm crops, and return about the same yields of these crops under comparable systems of management. Thus they are a basic management unit for common farm crops.

Capability units are then grouped into capability subclasses, a grouping that suggests both the degree and the kind of problem that a farmer or rancher will encounter in longtime use of the soil.

Capability subclasses, in turn, are grouped into capability classes, a grouping that expresses only the degree of limitation and risk for agricultural use.

This interpretation is widely used in giving technical assistance to farmers and ranchers through soil conservation districts. Soils are also grouped for special crops, for range sites, and for woodland suitability.

Land appraisers have found that soil surveys provide useful information on which to base land values, not only for individual tracts but especially to provide common standards for all holdings.

County and community planning officials are finding soil surveys of increasing value in helping to deal with the so-called "urban sprawl." Soil surveys show the areas most productive for agricultural products that may be needed in the future for a fast-growing population. They show areas that are less desirable for agriculture but that may be just as suitable for housing, schools, supermarkets, parking lots, and industry. With soil-survey information they can help direct the expansion onto land less productive for agriculture and thus help protect the food-production base for future use.

Soil surveys are being used increasingly for planning urban and suburban areas. The engineering interpretations dealing with the suitability of the soils for use in and support of roads, buildings, and other structures and for absorbing effluent from septic tanks are becoming more widely used.

The conservation engineers also have many uses for soils information. For example, they need to know how fast water enters the soil (intake rate) and how rapidly water passes through the soil. They need such information to lay out terraces and irrigation and drainage systems and to determine the size of dams needed to retard floods.

Foresters are learning a great deal about the relationships between kind of soil and woodcrop production, as well as related values such as for watersheds, recreation, and wildlife.

Wildlife conservationists find soil surveys helpful in planning and developing measures for protection and improvement of wildlife habitat.

A LAND-CAPABILITY MAP of a farm--an interpretation made from soil-survey information--being explained to soil conservation district supervisors.

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They may be used for evaluating habitat; for locating and building ponds for waterfowl; and in locating recreation, hunting, and fishing sites.

Oil and gas companies use soil surveys to plan the routes of pipelines where corrosion and cost will be least and to plan for erosion control after pipelines are installed.

Food processors and canneries want to locate their plants where they can be assured of a reliable source of raw materials. Soil facts help tell them where.

Investors, bankers, insurance companies, and building and loan companies find soil surveys helpful in determining the soundness of proposed investments in land. Farmers, or anyone who plans to buy a farm, will want to look first at the kind of soil and its potential productivity.

Manufacturers of earth-moving equipment need soils information in the design of certain types of machinery. The points of plows, blades of scrapers, and other similar cutters are affected greatly by the amount of sand and gravel in soils and in certain areas must be designed accordingly to allow for excessive wear.

Various organizations such as soil conservation districts, watershed conservancy districts, and drainage districts have need for soils information in developing district programs. A detailed soil survey actually forms the foundation for a soil conservation district's work by showing where in the district the most urgent work is needed, as well as what kind of program will be most beneficial.

The increasing importance of a watershed as a natural land unit for the application of soil conservation and water resource development programs recognizes the need for soil-survey information in watershed activities.

Research workers in experiment stations use soils information to set up crop and fertilizer studies. Soils data are used to predict soils responses to different levels of management. Extension workers and teachers use soil maps to help inform farmers and students on how to do a better job of farming.

Soil-Survey Reports

The findings of a soil survey are published as a soil map and a printed text that describes each of the soils, summarizes what is known about them, and explains their potential uses.

Most of the present reports are written primarily for agricultural users of the map. Most of them include additional information of value to engineers, foresters, geologists, land appraisers, and others. Since they report basic soils information, other interpretations for specific purposes can be made from them.

If the units on the map are properly described, the survey can be interpreted and reinterpreted as economic or other conditions change. Since yield predictions and management recommendations about a soil depend upon both the soil and the state of the agricultural arts, the development of new technology commonly requires new interpretations.

Most reports are published by the Soil Conservation Service in cooperation with the State agricultural experiment stations and with other cooperating agencies. The map scale is usually 1:20,000 which is slightly more than 3 inches to the mile. These maps are suitable for use in farm planning in most areas although in some a larger scale is needed.

While a survey is being made, work copies of unpublished soil maps are maintained usually in the local field office of the Soil Conservation Service, or in the soil conservation district office. Local soil handbooks and technical guides, available for reference only in the field office, are needed to interpret and use these unpublished maps.

Each soil conservation district cooperator is furnished a copy of the soil map of his farm and needed interpretations as a part of his farm conservation plan.

Soil-survey reports published by the United States Department of Agriculture that are still in print may be purchased from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

A copy of a report for a particular area is available free from the Soil Conservation Service to land owners or operators in the area and to professional workers who have use for them if the supply is not exhausted.

Extension services, experiment stations, and members of Congress may have copies of published reports for areas in their States.

County agents and SCS field offices usually have copies of the local soil-survey report if it has been published. A few State agencies also publish reports.

Many libraries have soil-survey reports for reference.

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